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Organic carbon storage in trees within different Geopositions of Chittagong (South) forest division, Bangladesh

Mohammed Alamgir [1], M. Al-Amin [2]

[1] *Department of Forestry and Environmental Science, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh*

[2] *Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong- 4331, Bangladesh*

Abstract: The organic carbon storage in trees and organic carbon flow with geoposition of trees was estimated in the forest area of Chittagong (South) Forest Division within geo-position 91°47' and 92°15' East longitude and 21°45' and 22°30' North latitude. The study was conducted through stratified random sampling by identifying each sampling point through Global Positioning System (GPS). It was found that above ground organic carbon storage (t/hm^2), below ground organic carbon (t/hm^2) and total biomass organic carbon (t/hm^2) was respectively the highest in *Dipterocarpus turbinatus* (Garjan) (7.9, 1.18 and 9.08 t/hm^2) followed by *Tectona grandis* (Teak) (5.66, 0.85 and 6.51 t/hm^2), *Artocarpus chaplasha* (Chapalish) (2.32, 0.34 and 2.66 t/hm^2), *Artocarpus lacucha* (Batta) (1.97, 0.29 and 2.26 t/hm^2) and *Artocarpus heterophyllus* (Jackfruit) (1.7 , 0.25 and 2.26 t/hm^2). From the study it was revealed that organic carbon stock was the highest (142.7 t/hm^2) in the geo-position 22° Latitude and 92° Longitude and was the lowest (4.42 t/hm^2) in the geo-position 21° 50' Latitude and 92° 2.5' Longitude. The forest of the study area is a good reservoir of organic carbon so has a good capacity to sequester organic carbon from the atmosphere. Sustainable forest management may help to sequester more organic carbon so that economic benefit for the country and environmental benefit in the international arena are possible from the study area.

Keywords: Bangladesh; Organic carbon storage; Forest; Sustainable management

Introduction

Global warming is amongst the most vital problems of the new millennium. Carbon emission is supposedly the strongest causal factor for global warming (Ravindranath *et al*. 1997). The carbon dioxide (CO_2) concentration in atmosphere increased from 280 ppm at the beginning of the industrial revolution to 368 ppm by the year 2000 and is projected to increase to 540 ppm by 2100 (Houghton *et al*. 2001). However, increasing carbon emission is one of today's major concerns, which is well addressed in Kyoto Protocol (Ravindranath *et al*. 1997). As a result of global warming the Indian subcontinent will experience an annual mean-averaged surface warming in the range between 3.5 and 5.5ºC by the 2080s (Lal 2001). In recent years among the few global issues that have received more attention of scientists, resource mangers, policy makers and the public undoubtedly is climate change (Tiwari *et al.* 1987). Forests play an important role in sequestration of carbon globally (Rawat *et al.* 2003). Ability of forests, trees and vegetation as terrestrial carbon sinks to absorb CO_2 emission and mitigate climate change has attracted wide attention (Gera *et al.* 2003).

Bangladesh has a total land area of 14.39 ×10^6 hm^2, of which 9.12×10^6 hm^2 is cultivated, 2.14 ×10^6 hm^2 public forests, 0.27×10^6 hm^2 village groves, and 1.64×10^6 hm^2 constantly under water. The remaining land area (1.22 ×10^6 hm^2) is occupied by tea gardens, uncultivable areas, rural and urban houses and ponds (Kibria *et al.* 2000). The area covered by government and village forests is about 16% of the total land area; however only 0.93 ×10^6 hm^2 (6.5%) is under tree cover, which is about 40% of the forests controlled by the government. The remaining 60% includes denuded lands (grassland, scrubland and encroached areas) (FAO 2003). In the global trends of forestry business, carbon sequestration has been emerged as a potential profitable business, which is oriented to socio-economic development and environmental amelioration. Estimates of carbon stocks and stock changes in tree biomass (above- and belowground) are required for reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and will be required for Kyoto Protocol reporting (Green *et al.* 2007). The Intergovernmental Panel for Climate Change has recently published Good Practice Guidance (IPCC GPG) for the reporting of land use, land use change and forestry activities (Penman *et al.* 2004). This guidance highlights the importance of nationally specific information, regarding a country's forest resources, in order to increase the transparency and verifiability of national carbon inventories (Green *et al.* 2007). In Bangladesh some sporadic works was done to estimate organic carbon in the plantation by Miah (2001, 2002) and Miah *et.al* (2002). The major part of the hill forest of Bangladesh is situated in Chittagong, Cox's Bazar and Sylhet forest Division. Quantification of the organic carbon stock in the forest of Bangladesh is impossible without estimating organic carbon storage in these forest areas. Presently very scanty information is available

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Biography: Mohammed Alamgir (1978-), male, Lecturer in Department of Forestry and Environmental Science School of Agriculture and Mineral Sciences Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh
E-mail: alamgirmd_2002@yahoo.com (Corresponding Author)
Responsible editor: Zhu Hong

about the organic carbon storage in these forest area so to get a clear picture of organic carbon storage in those forest, and present study was conducted within the Geoposition of Chittagong (South) Forest Division that enable the policy maker to take adequate steps to enrich and conserve the forest with the objectives of carbon sequestration and environmental amelioration in the international arena.

Materials and methods

Study site

The study area is the forest area of Chittagong (South) Forest Division. It lies within the geo-position 91°47' and 92°15' East longitude and 21°45' and 22°30' North latitude. It covers about 54004.2 hm^2 forest land (Mabud 2001). Chittagong (South) Forest Division consists of nine Ranges (sub division). The geology of the area has a complicated and relatively recent tectonic history. Soil is occupying the piedmont alluvial plains and valleys cover about one-fourth of the area (GOB, 1991). The study area has a moist tropical maritime climate, with high rainfall concentrated during the monsoon period from June to September. The relative humidity remains high, 70% to 85% with only minor variation throughout the year. Temperature also remains high with only small seasonal differences (Mabud 2001). The main species present are Chapalish, Telsur, Toon, Chandal, Am, Pitraj, and Jam *etc*. They are essentially evergreen with few deciduous or semi-deciduous species present. The undergrowth is dense with canes, climbing bamboo, shrubs and climbers. The characteristic feature of secondary forest of this type is the gregarious occurrence of the several species of *Dipterocarpus* (Garjan) with few others in the upper canopy (Mabud 2001).

Sampling procedure

The study was conducted using collected field data through physical measurement, field observation and laboratory analysis. The study was carried out over one year period from January 2004 to January 2005. Grid lines at the 2.5 ' intervals was inserted in the map from 91°47' to 92°15' East longitude and 21°45' to 22°30' North latitude of the studied area. In this way 102-intersection point was pointed in from the map. In the field each point was identified using Global Positioning System (GPS). Primarily Land use of each intersection point was identified in the field. In this way a total 31-intersection point in forest area of Chittagong (South) Forest Division was identified. Around each intersection point four sampling plots of 20 m×20 m were selected for tree species, in this way a total 124 sampling plots of 20 m×20 m for trees were studied and sample was collected from a representative tree of each species from each sampling plot for laboratory analysis to estimate organic carbon.

Biomass estimation

As the study was conducted in the forest and about 1 400 individuals of 144 tree species were measured in the sampling plots, it was not possible to cut all trees and to estimate biomass of trees. Consulting models developed by FAO (1997), Luckman *et al.* (1997), Negi *et al.* (1988) and Brown *et al.* (1989), Models of Brown *et al.* (1989) was used to estimate above ground biomass because literature showed this method was one of the most suitable methods for tropical forest (Alves *et al.* 1997; Brown 1997; Schroeder *et al.* 1997; FAO 1997). The model is as follows:

$$Y = \exp.\ \{ -2.4090 + 0.9522\ \text{In}\ (D^2HS)\} \qquad (1)$$

where, exp. = [……] means "raised to the power of […….]", Y is above ground biomass in kg, H the height of the trees in meter, D the diameter at breast height (1.3 m) in cm, and S the wood density in units of tonne pre m^3.
Below ground biomass was calculated considering 15% of the above ground biomass (Mac Dicken 1997).

Estimation of organic carbon storage in trees

After taking the fresh weight, collected samples were dried in the oven for 48 hours at 65ºC. Then dried weights were taken. Oven-dried grind samples are taken (1.00 g) in pre-weighted crucibles. The crucibles are placed in the furnace. Then the furnace was adjusted at 550ºC, heating was increased slowly and after reaching at 550ºC, ignition was continued for one hour. The crucibles were cooled slowly keeping them inside the furnace. After cooling, the crucibles with ash were weighted and percentage of organic carbon was calculated as Allen, *et al.* (1986).

$$A_{sh}\ \% = (W_3 - W_1) / (W_2 - W_1) \times 100$$
$$C\ \% = (100 - \%\ \text{ash}) \times 0.58$$

where, C is the organic carbon; W_1 the weight of crucibles, W_2 the weight of oven-dried grind samples + Crucibles, and W_3 the weight of ash + Crucibles.

Percentage of organic carbon with the above procedure was estimated for each sample. Then amount of organic carbon in the both above and below ground biomass of each tree was calculated separately and added finally to get total amount of organic carbon in the trees. Mean for organic carbon percentage, above ground organic carbon (t/hm^2), below ground organic carbon (t/hm^2) and total organic carbon (t/hm^2) was calculated from total individuals of a species and also converted for each species.

Result and discussion

Organic carbon storage

Organic carbon stocks in trees are shown in Table 1. It was revealed that *Linostema decandrum* has the highest mean value in above ground, below ground and total organic carbon (3.91 t/tree, 0.59 t/tree and 4.5 t/tree respectively) followed by *Mangifera sylvatica* (2.78, 0.42 and 3.20 t/tree), *Ficus bengale*nsis (3, 0.45 and 3.45 t/tree), *Tamarandus indica* (2.87, 0.43 and 3.30 t/tree), *Bichofia javanica* (2.70, 0.40 and 3.1 t/tree), *Baccaurea ramiflora* (2.37, 0.35 and 2.72 t/tree), *Artocarpus lacucha* (2.06, 0.31 and 2.37 t/tree), *Mesua ferra* (1.89, 0.28 and 2.18 t/tree), *Averrhoa billimbi* (1.80, 0.27 and 2.07 t/tree), *Tetrameles nudiflora* (1.74, 0.26 and 2 t/tree), *Terminalia bellirica* (1.62, 0.24 and 1.87 t/tree), *Albizia lebbeck* (1.6 , 0.24 and 1.84 t/tree), *Artocarpus chaplasha* (1.6, 0.24 and 1.84 t/tree), *Dipterocarpus turbinatus* (1.58 , 0.24 and 1.82 t/tree), *Saraca asoca* (1.56, 0.23 and 1.79 t/tree), *Ficus racemosa* (1.52, 0.23 and 1.75 t/tree), *Chickrassia tabularis* (1.55, 0.23 and 1.78 t/tree), *Terminalia chebulla* (1.51, 0.23 and 1.74 t/tree), *Ficus hispida* (1.46, 0.22 and 1.68 t/tree), *Syzygium grande* (1.42 , 0.21 and 1.63 t/tree),

Aphanamixis polystachya (1.57, 0.24 and 1.81 t/tree), *Albizia procera* (1.39, 0.21 and 1.59 t/tree), *Bombax ceiba* (1.33, 0.2 and 1.53 t/tree) and *Albizia falkataria* (1.31, 0.2 and 1.5 t/tree). The rest of tree species have less than 1.5 t/tree mean total organic carbon in the study area.

From the study it was depicted that above ground organic carbon (t/hm^2), below ground organic carbon (t/hm^2) and total biomass organic carbon (t/hm^2) was the highest in *Dipterocarpus turbinatus* (7.9, 1.18 and 9.086 t/hm^2 respectively) followed by *Tectona grandis* (5.66, 0.85 and 6.51 t/hm^2), *Artocarpus chaplasha* (2.32, 0.34 and 2.66 t/hm^2), *Artocarpus lacucha* (1.97, 0.29 and 2.26 t/hm^2), *Artocarpus heterophyllus* (1.7, 0.25 and 2.26 t/hm^2), *Albizia lebbeck* (1.93, 0.29 and 2.22 t/hm^2), *Albizia procera* (1.7, 0.25 and 1.95 t/hm^2), *Mangifera sylvatica* (1.71, 0.25 and 1.96 t/hm^2), *Bombax ceiba* (1.67, 0.25 and 1.92 t/hm^2), *Terminalia bellirica* (1.49, 0.22 and 1.72 t/hm^2), *Terminalia chebula* (1.32, 0.19 and 1.51 t/hm^2), *Lagerstroemia speciosa* (1.30, 0.2 and 1.5 t/hm^2), *Syzygium grande* (1.17, 0.17 and 1.34 t/hm^2), *Ficus bengalensis* (1.14, 0.17 and 1.31 t/hm^2), *Duabanga grandifolia* (0.97, 1.45 and 1.12 t/hm^2), *Hopea odorata* (0.92, 0.14 and 1.06 t/hm^2) and *Mangifera indica* (0.92, 0.14 and 1.06 t/hm^2). Among 144 tree species remaining species contain less than 1 t/hm^2 organic carbon.

Table 1. Organic carbon stock in trees within Geoposition of Chittagong (South) Forest Division, Bangladesh

Sl no.	Scientific name	Mean organic carbon percent	Mean above ground organic carbon (t/tree)	Mean below ground organic carbon (t/tree)	Mean organic carbon (t/tree)	Above ground organic carbon (t/hm^2)	Below ground organic carbon (t/hm^2)	Total organic carbon (t/hm^2)
1	*Albizia lebbeck*	53.4	1.60	0.24	1.84	1.929	0.289	2.218
2	*Albizia falkataria*	52.56	1.31	0.20	1.50	0.458	0.069	0.527
3	*Adina cordifolia*	55.19	0.45	0.07	0.52	0.141	0.021	0.162
4	*Aegel marmelos*	55.37	0.73	0.11	0.83	0.187	0.028	0.215
5	*Albizia chinensis*	52.88	0.98	0.15	1.13	0.441	0.066	0.507
6	*Albizia procera*	52.44	1.39	0.21	1.59	1.698	0.255	1.953
7	*Albizia saman*	53.03	0.62	0.09	0.72	0.664	0.1	0.764
8	*Alstonia scholaris*	55.49	0.79	0.12	0.91	0.519	0.078	0.596
9	*Anacardium occidentali*	56.6	0.61	0.09	0.70	0.187	0.028	0.215
10	*Anisoptera scaphula*	55.45	0.73	0.11	0.84	0.336	0.05	0.386
11	*Anogeissus acuminata*	51.79	0.27	0.04	0.31	0.173	0.026	0.199
12	*Anthocephalus chinensis*	54.7	0.83	0.12	0.95	0.123	0.018	0.141
13	*Antidesma ghaesembilla*	51.37	0.97	0.14	1.11	0.193	0.029	0.222
14	*Aphanamixis polystachya*	56.32	1.58	0.24	1.81	0.84	0.126	0.966
15	*Aporusa dioica*	54.22	0.13	0.02	0.15	0.037	0.006	0.043
16	*Areca catechu*	50.31	0.47	0.07	0.55	0.075	0.011	0.086
17	*Artocarpus chaplasha*	56.22	1.60	0.24	1.84	2.319	0.348	2.667
18	*Artocarpus heterophyllus*	50.05	0.62	0.09	0.72	1.702	0.255	1.958
19	*Artocarpus lacucha*	53.66	2.06	0.31	2.37	1.968	0.295	2.263
20	*Averrhoa billimbi*	50.57	1.80	0.27	2.07	0.257	0.039	0.296
21	*Averrhoa carambola*	53.59	0.53	0.08	0.60	0.055	0.008	0.063
22	*Azadiracta indica*	55.87	1.09	0.16	1.25	0.42	0.063	0.483
23	*Baccaurea ramiflora*	54.58	2.37	0.35	2.72	0.563	0.084	0.647
24	*Baringtonia cutangulata*	48.4	0.34	0.05	0.39	0.036	0.005	0.041
25	*Bichofia javanica*	53	2.71	0.41	3.11	0.519	0.078	0.596
26	*Bombax ceiba*	54.71	1.33	0.20	1.53	1.672	0.251	1.923
27	*Borassus flabellifer*	49.61	0.40	0.06	0.46	0.064	0.01	0.073
28	*Bursera serata*	52.6	1.20	0.18	1.39	0.413	0.062	0.475
29	*Butea monosperma*	55.78	1.91	0.29	2.20	0.838	0.126	0.964
30	*Callicarpa arborea*	51.65	1.03	0.15	1.18	0.206	0.031	0.237
31	*Callicarpa tomentosa*	52.4	0.18	0.03	0.21	0.05	0.007	0.057
32	*Carallia lucida*	51.23	0.11	0.02	0.13	0.012	0.002	0.014
33	*Cassia fistula*	55.86	0.45	0.07	0.52	0.192	0.029	0.221
34	*Cassia nodosa*	54.52	0.96	0.14	1.11	0.188	0.028	0.217
35	*Cassia siamea*	52.32	0.32	0.05	0.37	0.102	0.015	0.118
36	*Castanopsis indica*	55.6	0.22	0.03	0.25	0.095	0.014	0.11
37	*Chickrassia tabularis*	55.62	1.55	0.23	1.78	0.841	0.126	0.967
38	*Cleidion speciflorum*	53.88	0.25	0.04	0.28	0.118	0.018	0.135
39	*Cinnamonum sp.*	55.42	0.21	0.03	0.24	0.046	0.007	0.052
40	*Cocos nucifera*	43.68	0.46	0.07	0.53	0.048	0.007	0.055
41	*Cordia dichotoma*	51.75	0.20	0.03	0.23	0.022	0.003	0.025
42	*Dalbergia sissoo*	55.87	0.39	0.06	0.45	0.168	0.025	0.193
43	*Delonix regia*	56.89	1.25	0.19	1.44	0.314	0.047	0.361
44	*Dillenia pentagyna*	50.54	0.20	0.03	0.23	0.066	0.01	0.076

Continued Table 1

Sl no.	Scientific name	Mean organic carbon percent	Mean above ground organic carbon (t/tree)	Mean below ground organic carbon (t/tree)	Mean organic carbon (t/tree)	Above ground organic carbon (t/hm^2)	Below ground organic carbon (t/hm^2)	Total organic carbon (t/hm^2)
45	*Dillinea indica*	55.34	1.10	0.16	1.26	0.112	0.017	0.129
46	*Diospyros peregrina*	54.7	0.75	0.11	0.87	0.076	0.011	0.088
47	*Diospyros ramiflora*	54.43	0.15	0.02	0.18	0.026	0.004	0.03
48	*Dipterocarpus alatus*	55.64	0.10	0.01	0.11	0.017	0.003	0.019
49	*Dipterocarpus costatus*	55.76	1.14	0.17	1.31	0.222	0.033	0.255
50	*Dipterocarpus turbinatus*	56.16	1.58	0.24	1.82	7.901	1.185	9.086
51	*Duabanga grandifolia*	53.62	1.23	0.18	1.41	0.972	0.146	1.117
52	*Elaeocarpus robustus*	52.9	0.31	0.05	0.35	0.115	0.017	0.132
53	*Emblica officinalis*	54.31	0.43	0.06	0.49	0.159	0.024	0.182
54	*Engelhardtia spicata*	54.45	0.17	0.03	0.20	0.038	0.006	0.044
55	*Erythina variegata*	50.54	1.09	0.16	1.26	0.654	0.098	0.752
56	*Feronia limonia*	51.73	0.32	0.05	0.37	0.035	0.005	0.04
57	*Ficus bengalensis*	55.68	3.01	0.45	3.46	1.142	0.171	1.313
58	*Ficus hispida*	54.89	1.46	0.22	1.68	0.704	0.106	0.81
59	*Ficus racemosa*	55.18	1.52	0.23	1.75	0.221	0.033	0.254
60	*Garcinia cowa*	56.2	0.37	0.06	0.43	0.059	0.009	0.068
61	*Gardenia coronaria*	51.16	0.27	0.04	0.31	0.058	0.009	0.066
62	*Garuga pinnata*	50.69	0.15	0.02	0.18	0.034	0.005	0.039
63	*Gelonium multiflorum*	50.74	0.19	0.03	0.22	0.043	0.006	0.049
64	*Glochidion lanceolarium*	51.24	0.16	0.02	0.18	0.043	0.007	0.05
65	*Glochidion multiflorum*	55.55	0.13	0.02	0.15	0.029	0.004	0.033
66	*Glochidion velutinum*	56.37	0.31	0.05	0.36	0.083	0.012	0.095
67	*Glycosmis arborea*	52.48	0.08	0.01	0.09	0.022	0.003	0.025
68	*Gmelina arborea*	56.3	0.32	0.05	0.37	0.673	0.101	0.774
69	*Grewia microcos*	47.18	0.38	0.06	0.43	0.118	0.018	0.136
70	*Holarrhena tidysenterica*	52.33	0.64	0.10	0.74	0.229	0.034	0.263
71	*Holarrhena pubescence*	53.73	0.45	0.07	0.52	0.096	0.014	0.11
72	*Holigarna longifolia*	53.84	0.39	0.06	0.45	0.062	0.009	0.072
73	*Hopea odorata*	56.4	0.72	0.11	0.83	0.92	0.138	1.058
74	*Illex godajam*	52.41	1.07	0.16	1.23	0.207	0.031	0.238
75	*Ixora sp.*	50.53	0.13	0.02	0.15	0.021	0.003	0.024
76	*Lagerstroemia parviflora*	50.66	0.75	0.11	0.86	0.226	0.034	0.26
77	*Lagerstroemia speciosa*	49.42	1.10	0.16	1.26	1.306	0.196	1.502
78	*Lannea coromandelica*	52.81	0.98	0.15	1.13	0.578	0.087	0.664
79	*Leea sambusina*	53.68	0.08	0.01	0.10	0.01	0.001	0.011
80	*Leucaena leucocephala*	50.89	0.11	0.02	0.12	0.042	0.006	0.048
81	*Linostema decandrum*	51.86	3.91	0.59	4.50	0.367	0.055	0.422
82	*Litchi chinensis*	53.31	1.06	0.16	1.22	0.32	0.048	0.368
83	*Litsea monopetala*	52.83	0.38	0.06	0.44	0.101	0.015	0.117
84	*Litsea polyantha*	53.26	0.21	0.03	0.24	0.068	0.01	0.079
85	*Morus alba*	53.89	0.35	0.05	0.41	0.037	0.006	0.043
86	*Mallotus Philipensis*	54.45	0.26	0.04	0.29	0.084	0.013	0.097
87	*Mallotus roxberghinus*	56.08	0.19	0.03	0.22	0.041	0.006	0.048
88	*Mangifera indica*	56.08	1.09	0.16	1.26	0.922	0.138	1.061
89	*Mangifera sylvatica*	55.56	2.78	0.42	3.20	1.706	0.256	1.962
90	*Melia sempervirens*	55.75	0.32	0.05	0.37	0.087	0.013	0.1
91	*Mesua ferra*	54.43	1.89	0.28	2.18	0.451	0.068	0.519
92	*Michali champaca*	55.94	0.72	0.11	0.83	0.293	0.044	0.337
93	*Micromelum pubsencens*	52.7	0.05	0.01	0.06	0.016	0.002	0.018
94	*Miliusa roxberghina*	54.01	0.38	0.06	0.44	0.082	0.012	0.094
95	*Mimusops elengi*	55.44	0.24	0.04	0.27	0.13	0.019	0.149
96	*Mitragyna parvifolia*	53.16	0.33	0.05	0.38	0.088	0.013	0.101
97	*Mocrocos paniculata*	55.42	0.48	0.07	0.56	0.127	0.019	0.146
98	*Murraya paniculata*	52.14	0.11	0.02	0.12	0.024	0.004	0.028
99	*Myristica infolia*	54.03	0.44	0.07	0.50	0.115	0.017	0.133
100	*Olea dioca*	53.95	0.05	0.01	0.05	0.008	0.001	0.009
101	*Phoenix sylvestris*	55.47	0.59	0.09	0.68	0.062	0.009	0.071

Continued Table 1

Sl no.	Scientific name	Mean organic carbon percent	Mean above ground organic carbon (t/tree)	Mean below ground organic carbon (t/tree)	Mean organic carbon (t/tree)	Above ground organic carbon (t/hm^2)	Below ground organic carbon (t/hm^2)	Total organic carbon (t/hm^2)
102	*Pithcellobium angulatum*	56.78	0.38	0.06	0.44	0.101	0.015	0.116
103	*Pongamia pinnata*	51.93	0.36	0.05	0.42	0.114	0.017	0.131
104	*Protium serratum*	56.05	0.11	0.02	0.12	0.042	0.006	0.049
105	*Psedium guajava*	55.53	0.09	0.01	0.10	0.035	0.005	0.04
106	*Pterocarpus indicus*	55.23	0.02	0.00	0.03	0.006	0.001	0.007
107	*Pterospermum acerifolium*	52.71	0.11	0.02	0.12	0.043	0.006	0.049
108	*Pterospermum semisagittatum*	53.55	0.05	0.01	0.06	0.014	0.002	0.016
109	*Quercus acuminata*	53.27	0.12	0.02	0.14	0.028	0.004	0.032
110	*Quercus spp.*	55.62	0.37	0.06	0.42	0.079	0.012	0.09
111	*Randia sp.*	54.02	0.10	0.01	0.11	0.017	0.002	0.019
112	*Swetenia mahagoni*	56.41	0.56	0.08	0.65	0.635	0.095	0.73
113	*Sapium baccatum*	55.06	0.27	0.04	0.31	0.073	0.011	0.084
114	*Saraca asoca*	55.35	1.56	0.23	1.80	0.303	0.045	0.349
115	*Schima wallichi*	54.57	0.32	0.05	0.36	0.085	0.013	0.098
116	*Schleichera oleosa*	55.42	0.20	0.03	0.23	0.055	0.008	0.063
117	*Shorea robusta*	57.28	1.14	0.17	1.31	0.459	0.069	0.527
118	*Spondias pinnata*	55.48	0.28	0.04	0.33	0.093	0.014	0.107
119	*Sterculia villosa*	56.23	0.55	0.08	0.64	0.199	0.03	0.229
120	*Sterospermum cheloniodes*	50.4	0.05	0.01	0.06	0.012	0.002	0.014
121	*Sterospermum personatum*	52.03	0.80	0.12	0.92	0.392	0.059	0.451
122	*Streblus asper*	56.14	0.12	0.02	0.14	0.049	0.007	0.056
123	*Suregada multiflora*	54.99	0.08	0.01	0.09	0.014	0.002	0.016
124	*Swintonia floribunda*	55.5	0.80	0.12	0.92	0.573	0.086	0.659
125	*Syzygium claviflorum*	51.74	0.16	0.02	0.19	0.044	0.007	0.051
126	*Syzygium cumini*	52.3	0.04	0.01	0.05	0.013	0.002	0.015
127	*Syzygium fruticosum*	52.51	0.23	0.03	0.26	0.061	0.009	0.07
128	*Syzygium grande*	52.71	1.42	0.21	1.63	1.17	0.176	1.346
129	*Syzygium sp.*	53.05	0.18	0.03	0.21	0.03	0.004	0.034
130	*Syzygium syzynioides*	53.06	0.23	0.03	0.26	0.037	0.006	0.042
131	*Tamarandus indica*	48.52	2.87	0.43	3.30	0.417	0.063	0.48
132	*Tectona grandis*	54.93	1.25	0.19	1.44	5.662	0.849	6.511
133	*Terminalia arjuna*	48.17	0.41	0.06	0.47	0.129	0.019	0.148
134	*Terminalia bellirica*	49.88	1.62	0.24	1.87	1.495	0.224	1.719
135	*Terminalia catappa*	55.52	0.80	0.12	0.92	0.357	0.054	0.41
136	*Terminalia chebula*	54.8	1.51	0.23	1.74	1.319	0.198	1.517
137	*Tetrameles nudiflora*	54.82	1.74	0.26	2.00	0.17	0.025	0.195
138	*Toona ceiliata*	54.4	0.48	0.07	0.55	0.854	0.128	0.982
139	*Trewia orientalis*	55.22	0.05	0.01	0.05	0.008	0.001	0.01
140	*Vitex glabrata*	56.25	0.24	0.04	0.28	0.118	0.018	0.136
141	*Vitex peduncularis*	53.53	0.21	0.03	0.24	0.057	0.009	0.065
142	*Xeromphiss*	44.96	0.17	0.03	0.20	0.046	0.007	0.053
143	*Zanthoxyllum rhetsa*	54.76	0.03	0.00	0.03	0.007	0.001	0.008
144	*Zizyphus mauratiana*	55.45	0.19	0.03	0.21	0.061	0.009	0.07

Flow of organic carbon stock in trees within Geo-position of Chittagong (South) Forest Division

Fig. 1 shows the organic carbon flow of tree biomass within geoposition lying in Chittagong (south) Forest Division. From the study it was revealed that the highest organic carbon stock was 142.7 t/hm^2 in the geo-position 22° Latitude and 92° Longitude and the lowest (4.42 t/hm^2) in the geo-position 21° 50' Latitude and 92° 2.5' Longitude. It also shows the trend line of organic carbon flow in the study area. This variation may result from variation in the growing stock of trees.

Another study conducted by Uddin (2002) in the Chittagong University Campus, Bangladesh found that above ground, below ground and total biomass organic carbon content in the *Dipterocarpus turbinatus* plantation was 128 t/hm^2, 19 t/hm^2 and 147 t/hm^2 that in *Chickrassia tabularis* plantation was 130 t/hm^2, 20 t/hm^2 and 150 t/hm^2 and in *Syzygium grande* plantation was 94 t/hm^2, 14 t/hm^2 and 108 t/hm^2, respectively. Comparing to the above research findings it can be assumed that the forest of the study area store less organic carbon than plantation in the Chittagong University Campus, Bangladesh. The forest of Bangladesh is in degraded condition throughout the country and also true for the study area. Though the environmental condition of the study area is very much suitable for tree growth as well as

carbon sequestration by forest vegetation but stocking in the forest is very poor which reduced the biomass content of the forest resulting in lower organic carbon stock. In plants, organic carbon is stored in the foliage, stems and root systems and, most important, the woody tissue in the main stems of trees. Another study conducted by Alamgir (2005) showed that shrubs strata contains 35% to 50% organic carbon of their biomass in both above and below ground biomass and herbs layer also contains around about 30% to 45% organic carbon of their biomass both above and below ground biomass in the geoposition lying within Chittagong (South) Forest Division. The higher percentage of organic carbon in the biomass of tree, shrubs, herbs and grasses indicates the suitability of climate to sequester more organic carbon in the study area. Global carbon is held in a variety of different stocks. Natural stocks include oceans, fossil fuel deposits, the terrestrial system and the atmosphere. In the terrestrial system carbon is sequestered in rocks and sediments, in swamps, wetlands and forests, and in the soils of forests, grasslands and agriculture. About two-thirds of the globe's terrestrial carbon, exclusive of that sequestered in rocks and sediments, is sequestered in the standing forests, forest under-story plants, leaf and forest debris, and in forest soils (Warren and Patwardhan, 2001). Tree act as carbon sinks when they absorb CO_2 from the atmosphere, and store the same in the form of wood (Rana, *et al.*, 2003). Hardwood contains about 48% of carbon in the form of cellulose in wood (Chaturvedi 1994). One ton of Carbon in the wood or forest biomass represents 3.67t of atmospheric carbon dioxide (Tunner *et al.* 1995). In the present study most of the tree species contains around 50% organic carbon of their biomass (Table 1).

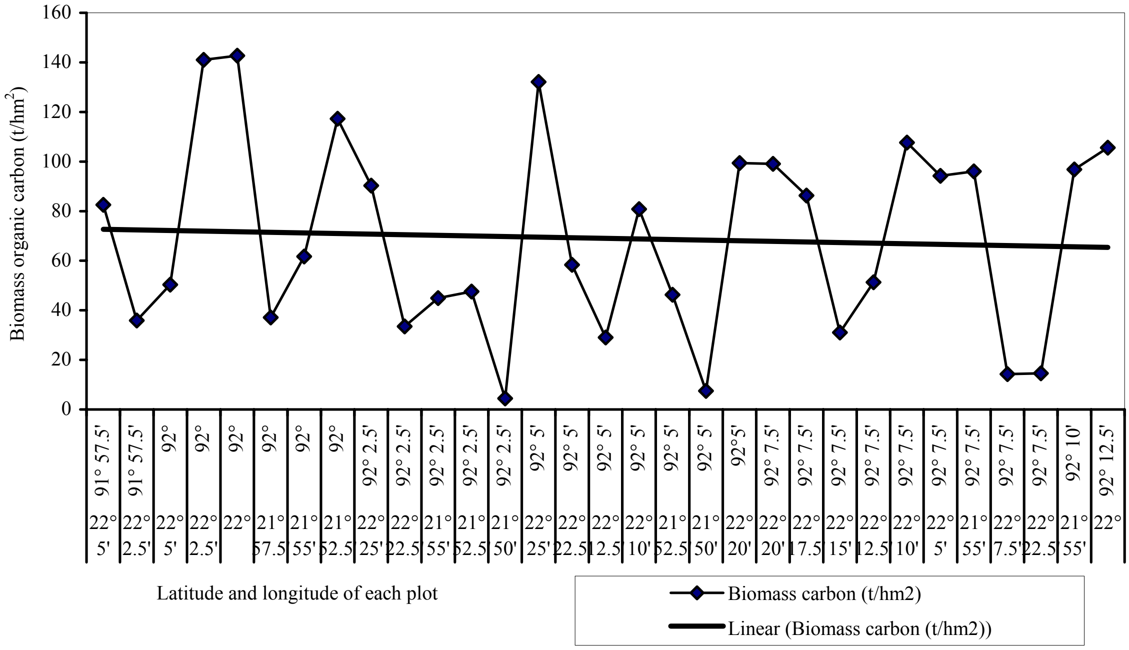

Fig. 1 Tree biomass organic carbon flow within geoposition of Chittagong (South) Forest Division, Bangladesh

Comparing to the above research findings it can be concluded that the trees within Geoposition of Chittagong (South) Forest Division can store a significant amount of atmospheric organic carbon if adequate protection is provided and reforestation in the bared hills through sustainable forest management is implemented. In this way we can help to reduce the global atmospheric organic carbon and global warming as well as can protect the country from severe environmental hazards because low-lying country like Bangladesh will go first under water resulting from sea level rise.

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